Haptic Board

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A multi-sensory simulator features a real-time simulation system and several peripherals, each being specialized to address one of the human sensory modalities [→ Multimodality, in cognitive sciences]. For sound and graphics, these peripherals are compose of:

- A device (e.g. a screen, loudspeakers, etc.) that transduces signals into/from the corresponding phenomenon
- A board (graphics or sound boards) that adapt signals or commands coming from the computer CPU into a signal usable by the devices.

The board embeds not only particular data input and output capabilities, but also various computation means dedicated to the device/modality they are designed for: a graphics board offers 3D processing, a sound board features filtering, spatialization, sometimes synthesis, etc. These computations are embedded to reduce the computer CPU load (indeed, some of these boards are not far from being as powerful as a computer), but also because they call for specific hardware architectures to be processed efficiently. Also, one can remark that graphics and audio boards features are now globally standardised (at least, their driver is: when the board actually does not implement a feature, the driver usually does, and runs the feature on the CPU). For example, all graphics boards feature openGL and DirectX, etc.

We define the haptic board as the component of a real time system for multi-sensory interaction that plays the role of a communication interface between the computer (e.g. in the case of simulation, the machine computing the simulated model) and the haptic device at hand [→ Haptics, haptic devices]. We summarize its main functionalities as follows:

- Transforming data from the haptic device to the computer CPU.
- Transforming data processed by the CPU back to the haptic device.
- Ensuring a matching between the two different signal structures and formats that are meaningful on the haptic device side on the one hand, and on the CPU side on the other hand.
- Realizing various computations specific to the above matching, and more generally specific to the needs of gesture interaction.

Today's haptic peripherals necessarily feature some of the above, sometimes reduced to standard anolog-to-digital/digital-to-analog converters. Also, most of them embed the signal processing into the electronics of the haptic device. This means that the haptic peripheral embeds in the same place both the functionalities of the device and those of the haptic board.

We consider that the haptic board deserves more attention: its today's characteristics are not yet satisfying. We assume that several of the main bottlenecks of real time platforms for multi-sensory simulation are related to the haptic board. A draft list of problems include:

- The latency introduced in data transmission, which has a particular impact on the reactivity of the simulation loop [→ Instrumental interaction]. We define latency as the time elapsed between the instant when the data is available on the gesture device, and the instant when it is available in the central simulator memory, or vice versa. Latency is mostly due to the time required by data transmission and the protocols it employs. Also, in the case of AD/DA conversion, the employed technology has a particular impact on latency.
- The available number communication channels. Gesture interaction may require a

many bidirectional channels (think about the piano keyboard with its 64 keys…), which is a technological bottleneck. Increasing the number of communication channels is a usual problem in computer hardware. A common solution consists in using temporal multiplexing, but it has a strong impact on transmission latency.
- The numerical format of the transmitted data. Gesture is a physical phenomenon involving a large range of dynamics [Luciani et al., 2006]. On the side of the device, haptic boards use data lengths of about 16 bits, while computer CPUs usually work with 32 bit or 64 bit data lengths. If the haptic board has to embed A/D conversion, digital precision becomes a bottleneck, since good precision is achieved at the expense of conversion latency.

Another problem is to define the dedicated computations that the haptic board could/should embed. What are the computations means needed inside the haptic board, and what hardware architecture do these call for? At least, we assume that one of the features of the haptic board should be to embed various gesture-related processing (e.g. physical simulation, haptic loop…) as close as possible to the device, in order to ensure the highest quality possible to the haptic interaction.

Finally, another major problem concerning haptic boards is standardisation (of the devices, of the gesture signal [→ Gesture and motion (encoding of)], of the computation within the haptic boards…). The field of haptics is still in its infanc, and standardisation is far from being achieved. Among the various reasons:
- Gesture is highly versatile. Depending on the targeted application field, the choices made lead to very different technical solutions and implementations. This involves the case of data formats to exchange gesture information, but also the mechanical structure of the haptic device, the actuating and sensing technology chosen, etc. All of these factors impact the haptic board.
- Signal inputs and outputs of the haptic device might take very different formats (in a very large meaning) depending on the actuating and sensing technologies. As an example, direct current (DC) brushless motors can receive pulse width modulation (PWM) digital inputs, while voice coils actuators usually don't. This means that a haptic board might or not be equipped with analog-to-digital or digital-to-analog converters.

Despite these difficulties and the bottlenecks to solve, we assume that haptic peripherals calls for the invention and the definition of dedicated haptic boards in a more or less near future, with their (very) specific features, architecture, and computation capabilities. A few research, indeed, are emerging – among which, within the Enactive Interfaces project, the work at ACROE.

References

[Luciani et al., 2006] Luciani, A., Evrard, M., Castagné, N., Couroussé, D., Florens, J.-L., and Cadoz, C. (2006). A basic gesture and motion format for virtual reality multisensory applications. In Proceedings of the 1st international Conference on Computer Graphics Theory and Applications (GRAPP), Setubal, Portugal.

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